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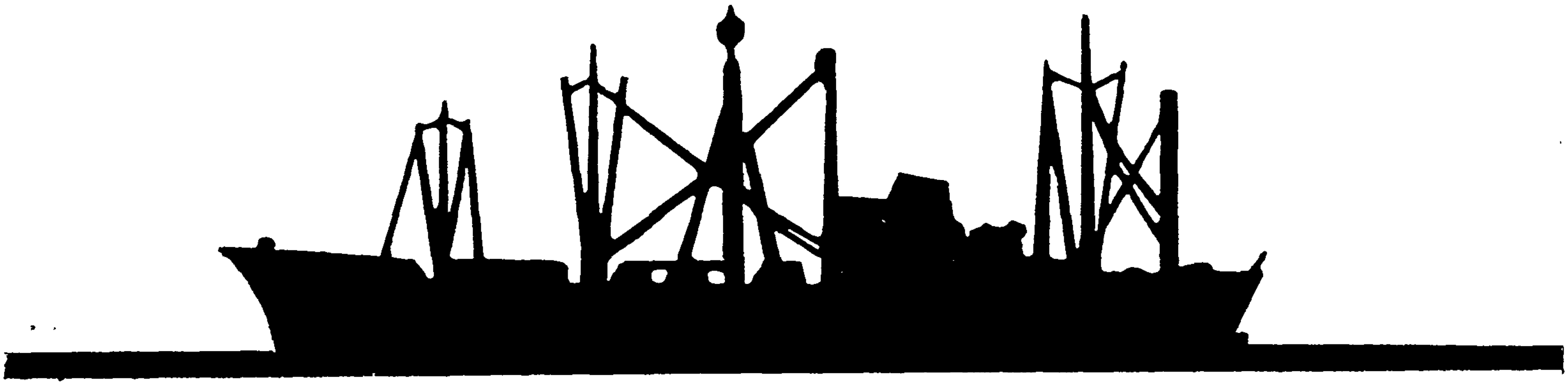

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

I R E A P S

SHIPBUILDING APPLICATIONS FOR THE ENGINEERING MODEL

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Mr. Baumgardner has extensive experience in the management of Engineering Design Modeling projects for the energy, aerospace, manufacturing and shipbuilding industries. He has directed numerous consulting and engineering design model programs for companies such as National Steel and Shipbuilding Company (NASSCO), Hughes Aircraft, TRW, Bechtel Power Corporation, Washington Public Power Supply, and Pacific Gas and Electric Company.

At Bechtel Power Corporation, Mr. Baumgardner worked as a Principle Engineering Model Deisgner for various nuclear power plant projects. While with McDonnell Douglas Corporation, Mr. Baumgardner served in both the manufacturing and manufacturing/engineering departments. In Japan, he was the Tooling Technical Assistant on a joint United States/Japan project. He was also Senior Project Tooling Engineer on various defense programs. As Manufacturing Program Manager, Mr. Baumgardner was responsible for a program with a $24 million manufacturing budget.

Mr. Baumgardner holds a MBA degree from the University of Illinois and a BS degree in mechanical engineering from the University of Illinois.

ABSTRACT

This paper is based mainly on the Model Builder's experience at the National Steel and Shipbuilding San Diego Yard while working on the Navy's T-ARC7 program. It will present varied uses for Engineering Models in the Shipbuilding Industry and will discuss improved planning and design, lower design and construction cost advantages and improved problem-solving techniques.

I would like to thank the IREAPS Technical Symposium for inviting me to present this paper. I hope it will be educational and will stimulate discussion.

For many people, mention of the word "MODEL" brings to mind model airplanes and railroads - those relatively inexpensive, mass produced replicas of the real thing. Such models are mainly for personal pleasure and are thought of as toys and playthings. If someone with this background sees the price tag of a hand fabricated, sophisticated engineering design model, his reaction is likely to be, "WHAT AN OUTRAGEOUSLY EXPENSIVE TOY!" If, in addition, this person has had some previous connection with a poorly planned, improperly staffed and badly run model program.... Well, the resulting attitudes are very predictable!

Now, suppose a ship machinery space engineering design model costs $400,000. (Did I hear a few gasps?) And suppose the hard cash savings is $600,000. In addition, let's suppose the customer is willing to pay for the cost of the model . . . .Sound interesting? If it is a multiple ship contract, it's looking even better! When evaluating a decision to use engineering models, we must look at the <u>VALUE</u> of the model, not just its cost.

For the past year and a half, Design Models, Incorporated (DMI) of Los Angeles has been building a 1½' = l'-0" (1/8th actual size) scale engine room model of a Navy cable laying and repair ship at the National Steel and Shipbuilding (NASSCO) San Diego Shipyard. The USNS Zues, designated T-ARC7, has the following principal characteristics. Overall length is 513'-6", with a beam of 73'-O", depth of 53'-0", design draft of 23'-10", displacement of 14,225 Tons and a power rating of 10,000 HP. Cruising speed is 15 Knots, with a cruising radius of 10,000 miles. The T-ARC7 is a diesel-electric ship. Five 2,500 Kw diesel generator sets power two 5,000 HP DC electric propulsion motors with direct drive, fixed-pitch propellers. The four 1,200 HP DC electric thrusters are tunnel type , two at the bow and two at the stern.

The model was set up as a design aid. It was initiated because of contract requirements by the United States Navy. However, since the model's inception, it has succeeded in winning wide acceptance by all levels of NASSCO personnel, and its role has greatly expanded.

NASSCO's in-house computer program for lines fairing was used to drive a drafting machine, tracing the frame shapes onto plywood. These sheets were cut out and used as templates for routing the frames from sheets of acrylic. Basic structure, model tables and equipment were fabricated at DMI's Los Angeles shop, then trucked to San Diego. Once there, the decks and equipment were assembled, and installation of piping, ventilation and cableways began.

In NASSCO's engineering building, space is at a premium. Therefore the original plan was to put the model in a building far removed from the design activity. Design Models fought hard to avoid this "KISS OF DEATH" for the model and finally convinced NASSCO management of the importance of placing the model on the machinery piping design floor. To accomplish this, the Commercial Ship Machinery Piping group and Mechanical group were moved into temporary trailers adjacent to the engineering building. The importance of location cannot be over-emphasized! Benefits derived from the model are somewhat like magnetism. Model usage is inversely proportional to the square of the distance between the model and the using agency. Double the distance, and derived benefits will be cut by a factor of four. For maximum benefit, the model must be at the point of usage - on the design floor during design and in the yard during construction.

Ten model bases, approximately 3 ft. by 4½% ft. by 7 ft. high, represented the machinery space. Two machinery rooms occupy the after one-quarter of the ship from keel to third deck. The ship was sized small for mission requirements, resulting in a very cramped machinery space. Ralph Bradford, NASSCO Chief Marine Engineer, compares the density in places to that found on nuclear submarines. The main design problem was one of trying to squeeze ten pounds into *a* five pounds sack!

The model served as a 3-dimensional composite, thus eliminating the need for costly composite drawings and their maintenance. The loss of composites caused initial misgivings among some NASSCO pernonnel; however, the tremendous aid to visualization gained through use of the model proved to far outweigh this loss.

As the model progressed, designers and yard personnel used the model more. They studied possible routings on the model. An occasional "Oh <u>*%#!!</u>" followed by a retreat to the board and the whir of an electric eraser were encouraging signs of the model's effective use. As NASSCO gained confidence in the model, DMI was allowed more freedom to do design work directly on the model. More drawings were made after the fact or were changed to correspond with routings developed on the model.

Now let's look at a few of the problems solved by this model.

Inner Bottom Saltwater Piping Redesign on the model, by DMI designers, reduced the 4" and 6" CuNi fitting by 25%.

Fuel Oil Transfer Line Redesign reduced the number of fittings on five, 4" steel lines from 40 to 10 and the number of direction changes from 75 to 45.

Main Propulsion Motor Foundation and Substructure Redesign increased strength and simplified design for improved produce-ability. Structural drawings were revised to dimensions developed on the model.

Electrical Cableway Redesign was required because of many interference problems found on the model. This is a diesel/electric ship, and the cableway density is very high. About 60% of all routings were changed. Isolation problems were also worked out on the model.

Fire Hose Lengthening resulted from running string from the various fire stations. 50 ft. lengths were found to be too short, so the hose length was increased to 75 ft.

Propulsion Switchboard Relocation was needed because of access door swing interference with stanchions. This would have been a very costly relocation if done on board ship after scribing, cutting and welding the switchboard to the deck!

Propulsion, Switchboard Overhead Clearance was increased after the problem was highlighted on the model. (The original clearance was only about 1".) Steel sizes were adjusted, giving a 3" minimum clearance.

7'-9" Level Grating Redesign on the model allowed installation per the engineering prints rather than costly development on board ship as was customary.

At this point, I think it is worthwhile to note that the problems mentioned so far were all created early in the program. In most cases, they resulted from designs made "independent" of the model. Later in the program, this type of problem was greatly reduced as designers learned to use the model in developing their designs, not just as an after-the-fact design checking device.

The model was used very successfully in the following areas:

Lighting Locations were developed on the model.

Access Forward of Machinery Room #2 Diesels was maximised using the model. Concerned Navy personnel were delighted with the final design.

Sloping Plumbing Lines Below the 3rd Deck were routed on the model. The galley is located above the switchboards, and gravity feed lines from the deck drain pots had very little room to maneuver as they sloped outboard to diverter stations.

Pre-outfitting the Underside of the 3rd Deck was smoothly accomplished with aid from the model. Pre-outfitting was unplanned until model designers pointed out the need based on cramped conditions above the switchboards and Enclosed Operating Space. Planning and sequencing for this operation were done using the model. It also proved invaluable in quickly solving problems encountered during the compressed-schedule pre-outfitting task.

I would love to talk about the many ways that models can benefit Engineering, Production, Planning and Scheduling, the Customer and Management, but time does not permit. I will include a summary of these benefits in the printed copy of this paper which will be sent to each of you after the symposium. At this point I think it is more important to look at the bottom line - COST SAVINGS, to look briefly at what the future may hold, and to leave a few minutes for questions and answers.

What were the cost savings derived from the T-ARC7 model? The total savings and impact will never be fully known. The only way to tell would be to reset the clock and run the same program with the same people without the model. This much can be said, however. The T-ARC7 is one of the most difficult machinery spaces designed and built by NASSCO. The design and construction has been accomplished smoothly without composite drawings but with an engineering model. Construction has progressed virtually free of problems caused by engineering design errors. Problems were successfully solved on the model, not on board the ship.

On an average machinery space, using composite drawings, NASSCO would expect about 225 Engineering Change Notices (ECN'S) on its machinery piping drawings alone. To date, on T-ARC7, there have been TWO ECN's! Installation of non-field-run machinery space piping is approximately 90% complete on the ship. Allowing for the increased complexity, let's conservatively say that the model saved just 225 ECN's. (The savings will be much greater when considering all engineering disciplines.) If we assume that the average cost per ECN is $1,500, that translates into savings of more than one-third of a million dollars. Elimination of machinery room composites might yield a savings of $110,000. Thus, looking at the resulting improvements in the machinery piping area alone shows savings in the neighborhood of a half million dollars. I am hopeful that NASSCO will run a comprehensive model cost effictiveness study at the end of the T-ARC7 project. I'm sure the total savings will be much higher.

The NASSCO Cost Engineering Department did do a cost feasibility study for commercial machinery space models. This study considered only the savings of eliminating composite drawings and of switching to single line piping drawings. These savings alone, more than covered the cost of a machinery space engineering design model.

I might point out that from the previous discussion, we saw how design savings were small when compared to savings realized in the yard.

Now, what does the future hold? Well, it looks like computer aided drafting is here to stay and that it will be playing an ever increasing role in the shipbuilding industry. Also, spurred on by the success of Japanese shipbuilders, it appears that U.S. shipyards will be using more modular construction techniques. How does the model fit in?

NASSCO has made a heavy commitment to use of computer aided drafting. Some of the machinery piping drawings for the T-ARC7 were drafted on the computer, and the designers made good use of the model. NASSCO designers and supervision find that CAD and the model compliment each other. There seems to be no conflict or duplication of effort. Each has its place, and both contribute to producing a superior design at a reduced cost.

More modular construction is being used by NASSCO on each new ship, but as yet, they have not made a total commitment to this approach as has the Avondale Shipyard in New Orleans. I visited this yard to talk with Tom Doussan, Vice President and Chief Engineer, and his staff. I toured the yard and witnessed their use of models as aids in construction of the modular units. Wherever I went, models were sitting by the modules as they were being constructed. Avondale has not used the model as extensively as they might have in the design area, but they are convinced of the value of this 3-dimensional aid to visualization in the yard during construction.

In conclusion: If properly planned, staffed and run, Engineering Model Programs in the Shipbuilding Industry work! They

* AID VISUALIZATION
* IMPROVE COMMUNICATIONS
* FOCUS AND COORDINATE DESIGN ACTIVITY
* SIMPLIFY PROBLEM SOLUTION
* EXPEDITE DECISION MAKING
* SIMPLIFY AND IMPROVE DESIGN
* ELIMINATE INTERFERENCES
* M O D E L S S A V E M O N E Y

MODEL BENEFITS FOR ENGINEERING

- **3-DIMENSIONAL VISUALIZATION**
- NO NEED FOR COMPOSITE DRAWINGS
- POSITIVE INTERFACE ELIMINATION
- FEWER DRAWING CHANGES
- REDUCED RESEARCH TIME
- SIMPLIFIED EVALUATION OF ALTERNATIVE DESIGN PROPOSALS
- ALLOWS USE OF PEOPLE WITH LOWER SKILLS AND EXPERIENCE
- SIMPLIFIED DRAWING CHECK
- EASY ACCOMODATION OF HUMAN FACTORS REQUIREMENTS
- SIMPLIFIED ENGINEERING / YARD LIASON FUNCTION
- IMPROVED DESIGNERS' SKILLS
- SINGLE LINE PIPING DRAWINGS

MODEL BENEFITS FOR PRODUCTION

- SOLVES INTERFERENCE ON MODEL, NOT ON BOARD SHIP
- PREVIEW FINISHED CONFIGURATION THROUGHOUT CONSTRUCTION
- ALLOWS PRODUCTION INPUT EARLY IN DESIGN PROCESS
- AIDS ERECTION AND ASSEMBLY SEQUENCING
- PERMITS MORE EFFICIENT PERSONNEL ALLOCATION AND SCHEDULING
- ALLOWS BETTER USE OF LESSER TRAINED PERSONNEL
- SHOWS PROGRESS STATUS AT A GLANCE
- AIDS IN INTERPRETATION OF ENGINEERING DRAWINGS

MODEL BENEFITS FOR PLANNING / SCHEDULING

- o BETTER VISUALIZATION OF OPTIMUM
  - ERECTION SEQUENCING
  - EQUIPMENT LANDING SCHEDULING
  - SYSTEM INSTALLATION SEQUENCING
- o BETTER IDENTIFICATION OF PRE- OUTFITTING REQUIREMENTS

MODEL BENEFITS FOR CUSTOMER

- 0 BETTER DESIGN
- 0 MORE COST EFFECTIVE DESIGN AND CONSTRUCTlON PROCESS
- 0 IMPROVED COMMUNICATIONS
- 0 SIMPLIFIED DESIGN REVIEWS
- 0 IDEAL OPERATOR TRAIMNING AID

MODEL BENEFITS FOR MANAGEMENT

- 0 CONTINUOUS 3-D DISPLAY OF DESIGN STATUS AND PROGRESS
- 0 QUICK AND EFFICIENT DESIGN REVIEWS
- 0 QUICK AND EFFICIENT PROBLEM SOLUTION
- 0 FOCAL POINT FOR FOR INTERDISCIPLINE COORDINATION
- 0 RAPID TRAINING OF NEW OR INEXPERIENCED PERSONNEL
- 0 SIMPLIFIED CUSTOMER COMMUNICATIONS
- 0 BETTER SCHEDULE COMPLIANCE
- 0 DESIGN CORRECTIONS ON MODEL, NOT ON BOARD SHIP
- 0 COST SAVINGS

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